Neutrino Lattice (NuLat): Raghavan Optical Lattice

General Ideas

for the NuLat Collaboration:

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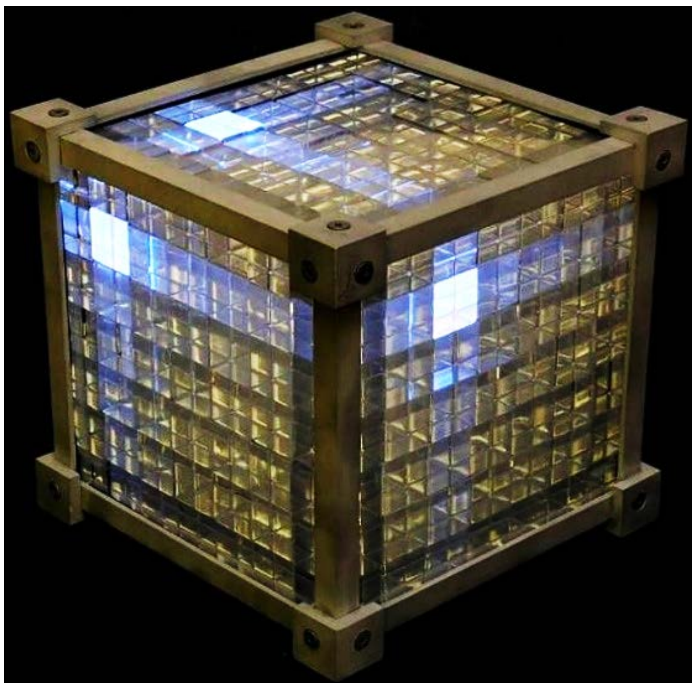
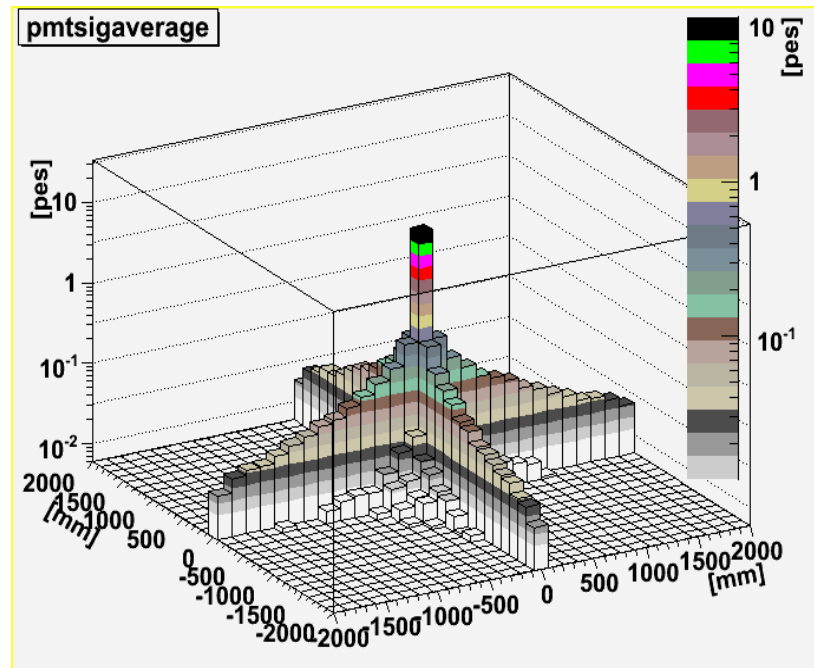
And a number of others who have helped along the way.





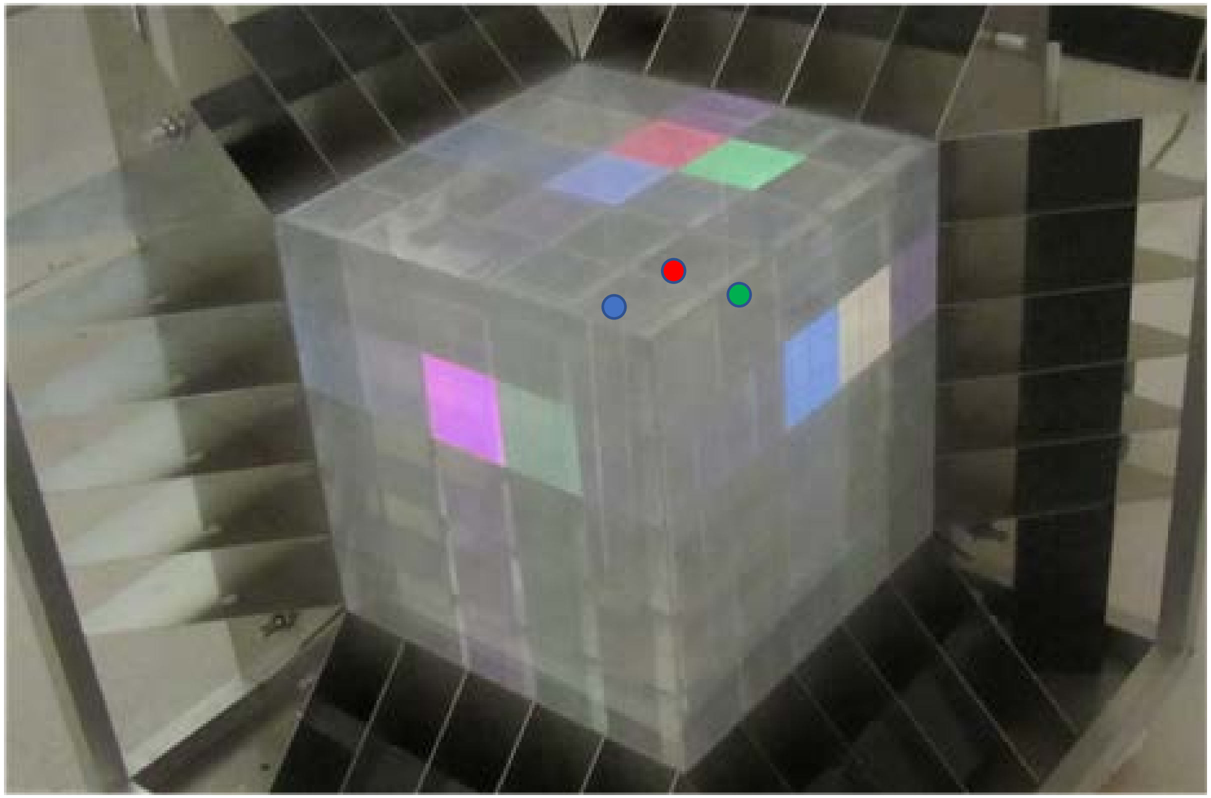
- light channeling via total internal reflection
- full 3D light collection along principle axes

Highly segmented, giving: spatial, temporal, and pulse-shape discrimination tags common to many detectors.

Additional handles on background rejection:

1) high resolution due to excellent light collection
2) true 3D channeled light collection
3) option for truly ‘wall-less’ segmentation.
4) energy deposition sequencing

Potential applications beyond reactor anti-neutrinos.

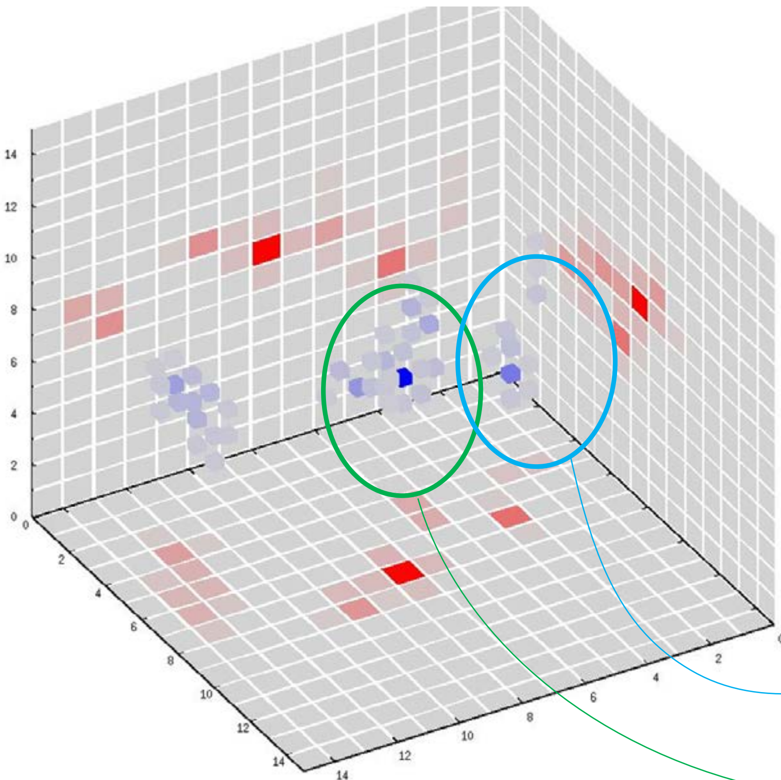


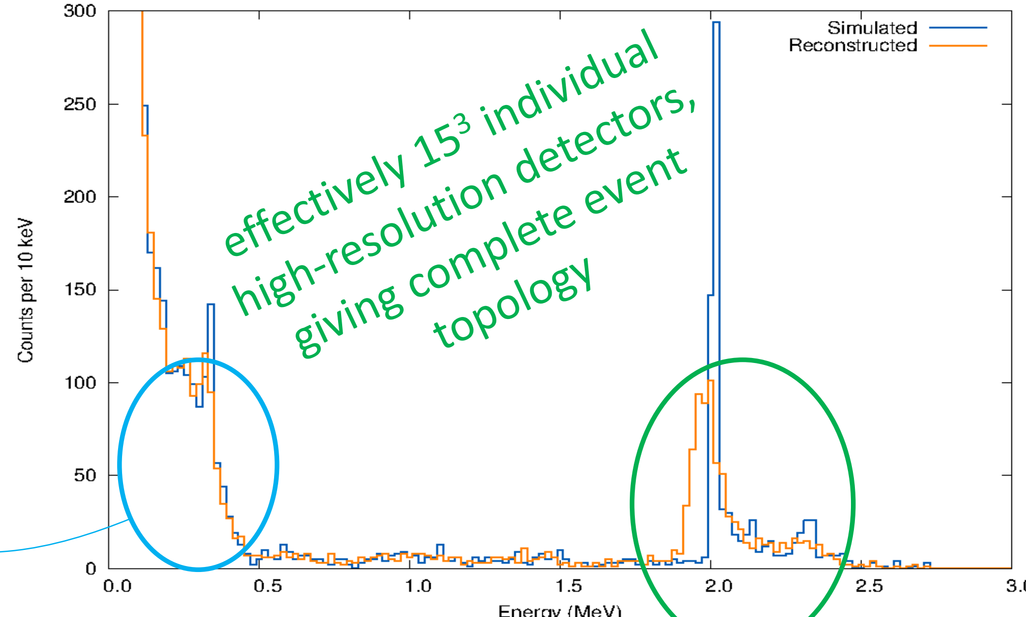
True image of three point-sources of light (r,g,b) in three cubes of the second horizontal plane.
(Light sources themselves not directly visible due to channeling. Light visible at surface of channels due to surface imperfections.)

1D (1-side): (red+blue=purple), green
2D (2-side): (red+blue=purple), green and (red+green=yellow),blue
3D (3-side): red, green, and blue directly separated on top face

Positron Event Topology

<4%/$\sqrt{E}$ (>600 p.e. /MeV)
single cell position (< 3 cm w timing)





Reconstruction of a typical 2 MeV positron event.
note: 3D allows digital separation of events ***along*** channel

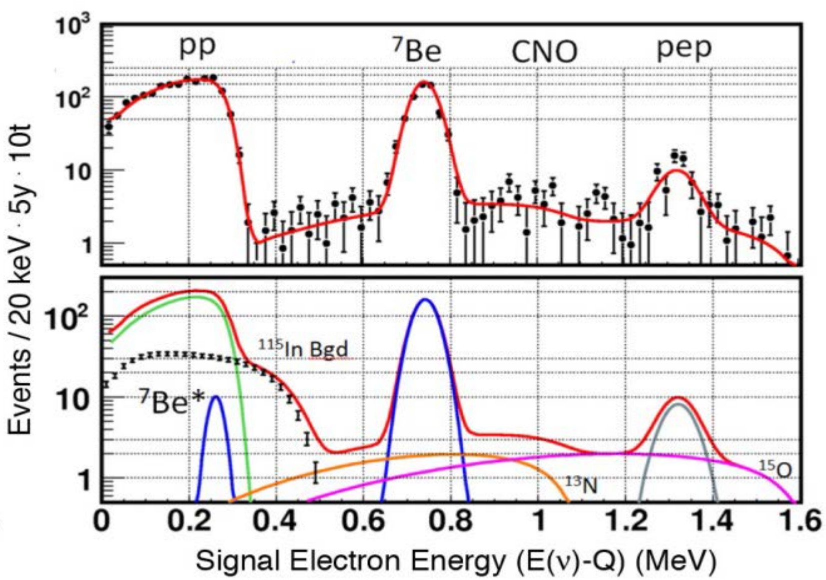
Average single-cell prompt response to a uniform 3.8 MeV anti-neutrino flux.
no fiducial cut

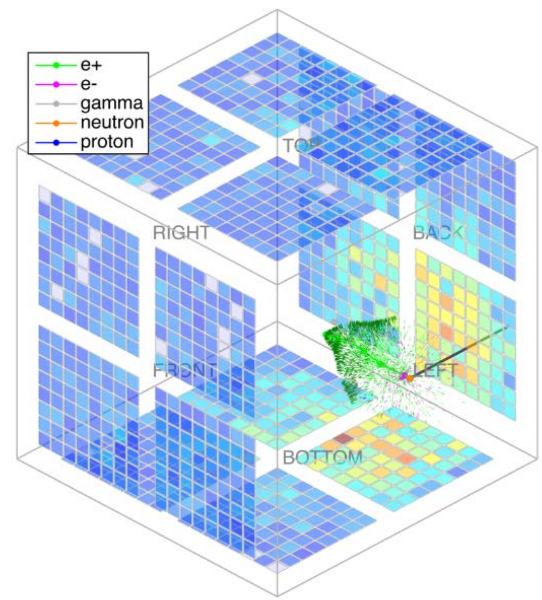
Knowing event energy-deposition topology through geometry, in principle allows time-ordering of energy depositions using timing.

e.g. You can not have the 511 keV annihilation radiation before the positron was produced.

Applications beyond anti-neutrinos.

- Neutrinos (not anti-neutrinos)
  - NSF supported R&D
  - solar neutrino spectrum
  - segmentation and event topology
  - In loaded scintillator
- TimeCube
  - DOE, NGA supported R&D
  - neutrino detection and fission neutron directional detection
  - very fast (< 0.1 ns) electronics





Air-gap technology for total-internal-reflection mirrors.

- Aerogel thin film between two plastic films allows optical mirror-sheets in even low-index aqueous solutions.
- Potential improvement in signal-to-background by limiting the number of PMTs light from events are channeled to.
- Can divide even large volume detectors into cubes, or planes, or regions (eg fiducial or near surface)

Most small anti-neutrino detector designs might also find future use to monitor Accelerator-Driven Subcritical Reactors

- Deliberately introduce short-time structure on the driving beam, to monitor the response of the reactor core. The time-scale can be such that average power production does not significantly change, but the multiplication can be measured.
- Can reveal if WGPu can be made, or only commercial grade Pu.

Invent the Future

GEM STAR

Cost
- mostly proven, known costs
- very competitive with fossil fuel
- simplified safety system
- reduced nuclear security cost

Nonproliferation
- no enrichment required
- no reprocessing (just fluorination)

Waste
- reduced by orders of magnitude
- can productively use today's LWR spent fuel (bulk fluorination)

Safety
- no concern for fuel melting (Accident Tolerant Fuel)
- Subcritical - no criticality accidents
- reduced volatile radioactive inventory
- low-pressure system

Timeline
- no missing technology
- reduced licensing time (system and public acceptance)